• Gas Filter Correlation Radiometry

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A. R. Barringer; R. Nichols; J. M. Russell III

• Spectral Radiometry and Tropospheric Aerosols

R. S. Fraser (Chairman)
M. Griggs; A. A. Lacis; L. R. McMaster

• Lidar Technology/Measurements

E. V. Browell and D. K. Killinger (Chairmen)
F. Allario; M. Bristow; H-Y Chiu; J. J. Degnan; D. E. Fitzjarrald
W. S. Heaps; C. L. Korb; J. B. Laudenslager, M. P. McCormick
I. S. McDermid; S. H. Melfi; V. A. Mohnen; R. Philbrick
A. Rosenberg; M. M. Sokoloski

The four measurement technology position papers form the bulk of this workshop report. As you will note, of the four measurement technology reports, the report from the lidar measurement technology panel is, by far, the longest. This is due to the fact that the 1981 NASA workshop only considered the role of passive remote sensors in measuring tropospheric trace species from space (see table I). Active remote sensors, i.e., lidar systems, were not considered at all in the earlier workshop.

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FUTURE INSTRUMENTATION AND MISSIONS FOR MEASUREMENTS OF TROPOSPHERIC TRACE SPECIES FROM SPACE: WORKSHOP RECOMMENDATIONS

After the four instrument/technology panels completed their assessment of the available and projected instrument possibilities and the required technological/scientific activities to accomplish these objectives, all of the workshop participants were divided into three tropospheric mission panels which cut across instrument/technology lines. The mission panels were asked to: (1) recommend a phased space-measurement program to meet the scientific needs of an aggressive global tropospheric chemistry program for three timeframes: the present, the near term (1986-1992), and from 1992-2000--the period when the EOS is scheduled to become operational, and (2) recommend a supporting research and development program to ensure the successful accomplishment of the objectives of (1).

After their deliberations, the three mission panels reported their recommendations to the entire workshop. Although they differed in their approachs, the recommendations of the three mission panels were almost identical. Their recommendations and potential missions are summarized here and in table III.

The workshop missions panels recommended that gas filter correlation radiometry and high-resolution interferometry be exploited and expanded for measurements of the distribution of tropospheric trace gases. Such instruments and missions were identified and discussed by the panels and several instrument/measurement/mission feasibility studies were recommended by the panels, including:

• A three-layer (lower, middle, and upper troposphere) measurement of carbon monoxide, using a nadir-viewing gas filter correlation radiometer.

- A lower or middle tropospheric measurement of methane, using a nadir-viewing gas filter correlation radiometer.

- A survey of lower, middle, and upper tropospheric trace gases using a nadir-viewing high-resolution interferometer operating in the thermal emission mode.

The mission panels also concluded that lidar systems appear to have the potential of obtaining measurements of tropospheric trace gases and aerosols from space. In anticipation of the actual demonstration of spaceborne lidar measurements of tropospheric trace gases and aerosols, several lidar technology and measurement feasibility studies were considered, including:

- Feasibility studies to consider the potential of obtaining measurements of tropospheric trace gases and aerosols from spaceborne lidar systems. As discussed in this report, the Lidar Measurements and Technology Panel considered tropospheric measurements of the distribution of aerosols, water vapor, ozone, carbon monoxide, methane, and, possibly, ammonia, as well as column measurements of tropospheric nitrogen dioxide and, possibly, nitric oxide and sulfur dioxide.

In addition to the specific instrument/mission recommendations, the panels made several general recommendations that may lead to future spaceborne instruments, techniques, and missions for tropospheric chemistry research. This research may result in more accurate and/or faster algorithms and techniques for the retrieval and inversion of spaceborne radiative data for future tropospheric missions and in the possible development of new technologies for spaceborne measurements of tropospheric trace gases. The panels recommended research into the following areas:

- Basic studies in tropospheric radiative transfer and spectroscopy, e.g., line mixing in carbon dioxide, line shapes (especially for water vapor), and the behavior of the continuum.

- Basic research and development in detectors, coolers, and submillimeter and microwave components for the next generation of tropospheric spaceborne instrumentation; basic research and development aimed at improving existing laser efficiency, lifetime, and spectral quality and the development of new lasers for spaceborne measurements of tropospheric gases.

Spaceborne missions for tropospheric trace gases and aerosols presently available and projected for the future are summarized in table III.

A summary of the workshop, including a discussion of the scientific and technological challenges of obtaining measurements of tropospheric trace gases and aerosols from space, was reported in a paper presented at the American Meteorological Society Second Conference on Satellite Meteorology/Remote Sensing and Applications, Williamsburg, Virginia, May 13 to 16, 1986 (Levine et al., 1986).

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TABLE I.- TROPOSPHERIC TRACE GAS MEASUREMENTS FROM SATELLITES

(National Academy of Sciences (1985)

	Gas	Concentration (V/V)
First Level		
	H_2O	0.05- 0.04
	O_3	40 -100 ppb
	CO	0.05- 0.3 ppm
	CH_4	1.7 ppm
Second Level		
	N_2O	0.3 ppm
	NO_2	0.01- 10 ppb
	NH_3	0.1 - 1 ppb
	SO_2	0.05- 1 ppb
	Chlorofluoromethanes	0.2 ppb
	$HC\ell$	0.1 - 1 ppb

TABLE II.- NASA WORKSHOPS AND REPORTS ON TROPOSPHERIC CHEMISTRY

(Listed in Chronological Order)

Levine, J. S. and D. R. Schryer (eds.), Man's Impact on the Troposphere - Lectures in Tropospheric Chemistry, NASA Reference Publication 1022, 376 pages, 1978.

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Hoell, J. M. (ed.), Assessment of Techniques for Measuring Tropospheric H_xO_y (Proceedings of a workshop held in Palo Alto, CA, Aug. 16-20, 1982), NASA Conference Publication 2332, 138 pages, 1984.

Crosley, D. R. and J. M. Hoell (eds.), Future Directions for H_xO_y Detection (Proceedings of a workshop held in Menlo Park, CA, Aug. 1985), NASA Conference Publication 2448, 65 pages, 1986.

TABLE III.- TROPOSPHERIC MISSIONS: 1985-2000

Species	Instrument	Comments
1. Past and Present		
CO (Mid Trop.)	MAPS	Flown on Space Shuttle--two flights (Nov. 1981; Oct. 1984)
H_2O, O_3, Aerosols (Mid to Upper Trop.)	SAGE II	On ERBS (Launched Oct. 1984)
Several Gases (Mid to Upper Trop.)	ATMOS	SPACELAB 3 (April-May 1985)
Aerosols	AVHRR	NOAA Polar-Orbiting Operational Environmental Satellite (POES)
	VISRR	NOAA Geostationary Operational Environmental Satellite (GOES)
	Multispectral Sensors	LANDSAT
2. Potential Future Near-Term Missions (Through 1992)		
CO (Three Layers: (Lower, Middle, and Upper Trop.)	Gas Filter Correlation Radiometer--Nadir-Viewing Mode	Should be studied
CH_4 (Lower or Middle Trop.)	Gas Filter Correlation Radiometer--Nadir-Viewing Mode	Should be studied
Several Gases (Lower, Middle, and Upper Trop.)	High Resolution Interferometer--Thermal Emission Mode)	Should be studied
Aerosols	LITE (Lidar in Space Technology Experiment	Planned for 1989 flight of Space Shuttle as a technology demonstration